CLAIMS:

1. **Apparatus for providing an indicator of or from which stiffness can be estimated for elongate timber, logs or felled tree stems (hereafter "logs") of known length L or measurable length L,** said apparatus comprising or including

sensing means capable of being placed in contact with or in close proximity to a log end to detect the impulse and echoes thereof resulting from a striking of the other or that same log end,

processing means to derive using an echo or echoes sensed by said sensing means a said indicator, and

display means to display said indicator or any derivative thereof received from said processing means,

wherein said processing means tests algorithmically frequency transformed data derived from *time based* echo data with a view to deriving a measure or good estimate of fundamental frequency f_0,

and wherein L is or can be entered into said processing means,

and wherein said processing means derives said indicator by reference to both f_0 and L.

2. Apparatus as claimed in claim 1 wherein said processing means tests all spectral peaks of the echo data for membership of a series from which a best value of fundamental frequency f_0 can be derived and related to the plane wave speed V and specimen length L by $V = 2L/f_0$ rather than by reliance on the identification of any single resonance peak.

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3. Apparatus as claimed in claim 1 or claim 2 wherein said processing means recognises that the characteristic frequencies may be shifted significantly from a harmonic series f_0, $2f_0$, $3f_0$ ..... set and recognises that a better indication of the fundamental frequency f_0, from which the speed V can be found is obtained from higher harmonics.

4. Apparatus as claimed in claim 3 wherein said processing means recognises that a better indication of the fundamental frequency f_0 than an attempted direct measure of f_0 itself is from at least the second harmonic.

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5. Apparatus as claimed in any one of the preceding claims wherein said processing means recognis s that whilst the natural resonance frequencies of stems and logs may be far from harmonic (principally on account f the asymmetry introduced by their taper or loading eg; when stacked) they may be transformed to a harmonic series by

applying a correction which decreases as the harmonic number increases.

6. Apparatus as claimed in claim 5 wherein said processing means can transform observed series of resonant frequencies f_n into multiples of a "true" fundamental frequency f_0 from which a plane wave velocity can be derived by reliance upon the relationship $(f_n - n f_0)/f_n = ke^{-n}$.

7. Apparatus as claimed in claim 6 wherein said the fractional deviation falls in geometric progression with ratio approximately 2.7.

8. Apparatus as claimed in claim 6 or claim 7 wherein the relationship is $f_n/nf_0 - 1 = k/n^2$.

9. Apparatus as claimed in any one of the preceding claims wherein said processing means discriminates against noise spikes in the spectra, peaks from unwanted modes inadvertently excited, or any other signals which differ from the spectral peaks sought and which have the desired relationship by using a comb filter comprising a number of frequencies ("centre" frequencies) which match the sought relationship, which can themselves be harmonic or have some other relationship, the comb filter having passbands wide enough to allow small deviations about each centre frequency,

forming the sum of the products of the actual spectral peaks and the comb filter, and

identifying as the sequence or filter which accounts for most spectral power, and, where necessary.

deciding between two filters which produce equal power sums on the basis of the comb which produces the least frequency offset between the actual spectral peaks and the filter centre frequencies.

10. Apparatus as claimed in any one of claims 6 to 8 wherein said processing means uses such transforms to convert a harmonic series with a defined base frequency f_0 to a non-harmonic series, thereby defining the centre frequencies of a comb filter with which the actual series may be compared, without the need for all members of the actual series to be present.

11. Apparatus as claimed in any one of the preceding claims wherein said processing means can calculate a confidence number to be displayed by said display means to indicate the likelihood that the indicated velocity is correct or whether a re-measure is advisable based on the amount of power in the spectral peak series identified with a base value of f_0, compared with spectral power not accounted for, e.g that assumed to be in spurious noise spikes or non-longitudinal resonances inadvertently excited.

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12. Apparatus of any one of the preceding claims wherein said indicator is V or V^2 or a function of V or a function of V^2.

13. Apparatus of claim 12 wherein said indicator is V^2 or a function of V^2 derived from a value or function of V, V having been determined by $V = 2L f_0$.

14. Apparatus of claim 13 wherein said display means displays V^2 or an indicator or indicators of the one or more properties being assessed, such as MOE or an approximation of MOE derived from $MOE = \rho V^2$ where ρ has been approximated (e.g. as near 1000 kg/m^3 for green felled logs).

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15. Apparatus of any one of the preceding claims wherein said sensing means and/or processing means includes amplification means to ensure a sufficient gain to ensuing echos in use.

16. Apparatus of any one of the preceding claims wherein said sensing means is adapted to be place in contact with a said log end.

17. Apparatus of any one of the preceding claims wherein said sensing means carries a switch for said processing means conducive, when activated, of good log/sensing means contact.

18. Apparatus as claimed in any one of the preceding claims wherein said sensing means is compliantly mounted by a sensing head to be physically pressed by a user against the log surface to be tested.

19. Apparatus of claim 18 wherein the compliant mounting of said sensing means within the means to be handled by a user i.e. the sensing head, is compliantly mounted by use of silicone rubber.

SUB A6

20. Apparatus as claimed in claim 18 or 19 wherein said sensing means is in a sensing head connected by flexible means to apparatus carrying said processing means and said display means.

21. Apparatus as claimed in any one of the preceding claims wherein said sensing means is or includes a piezo-style accelerometer.

22. Apparatus as claimed in any one of the preceding claims wherein said processing means has analog signal acquisition means, means for digitization and processing into a characteristic spectrum of the acquired analog signal data of the echoes and furth r software algorithms to interpret the data.

23. Apparatus of any one of the preceding claims wherein, with a view to power saving, said display means is a small low power display.

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24. Apparatus of any one of the preceding claims wherein said sensing means is in a sensing head capable of one handed manipulation by a user and whereby the apparatus is adapted to minimise power consumption by allowing initiation of the measurement sequence by finger pressure on a push switch immediately prior to the striking of a log to be tested, such pressure on such a push switch encouraging positive contact between the head and the log surface.

25. Apparatus as claimed in any one of the preceding claims wherein said processing means is adapted to threshold the signal from said sensing means and immediately to apply an exponentially increasing amplification of the signal to compensate for absorption of the signal in the log so increasing the time over which acoustic signals can be usefully digitalised and to increase spectral resolution.

26. Apparatus as claimed in any one of the preceding claims in which power consumption is adapted to be minimised by allowing operation under the control of PLDs which remain in low current mode until enabled by an initiation switch after which there is a powering up, at least as needed, of analogue functions of said processing means with respect to signal acquisition, powering up and analysis of such signals and a sending results to the display means before being subsequently powered down after a time period or time periods.

27. Apparatus as claimed in any one of the preceding claims wherein there is provided a keyboard through which data entries can be made into said processing means.

28. Apparatus as claimed in claim 27 wherein preset information for data entry is selected from the class any one or more of

(i) velocity class codes e.g. colours to be painted on a log after its speed group is determined,

(ii) log length codes,

(iii) information analysis purposes,

(iv) information for instrument configuration purposes, and/or

(v) to control the sending of spectral information via a serial port to an external computer for graphical display or archiving.

29. Apparatus as claimed in any one of the preceding claims having a hardware architecture substantially as hereinbefore described with reference to the accompanying drawings and which is operable in a manner substantially as hereinbefore described with reference to any one or more of the accompanying drawings.

30. Apparatus of any one of the preceding claims wherein said sensing means is adapted to be placed at or in close proximity to the same log end as that to be struck to provide said impulse.

31. **A method of providing an indicator of or from which stiffness, fibre characteristics or other properties can be estimated,** which method involves an operative use of apparatus as claimed in any one of the preceding claims.

32. A method of claim 31 performed substantially as hereinbefore described with or without reference to any one or more of the accompanying drawings.

33. **A method of providing an indicator of or from which stiffness, fibre characteristics, or other properties can be estimated for a felled log of known or measurable length L,** said method comprising or including the steps of

striking an end of the felled log whilst having sensing means of the previously defined apparatus in contact with or in close proximity to a log end to detect at least one echo of the impulse resulting from the striking of that same or the other log end,

processing the output of at least said sensing means in said processing means to derive, using an echo or echoes sensed by said sensing means, a said indicator, and

displaying on or by said display means said indicator or any derivative thereof received from said processing means,

optionally thereafter appropriately marking or otherwise indicating the fate of the log on the basis of the displayed indicator,

said process being further characterised in that said processing means tests frequency transformed data derived from time based echo data with a view to deriving a measure or good estimate of fundamental frequency f_0, L is or can be entered into said processing means, and said processing means derives said indicator by reference to both f_0 and L.

34. A method as claimed in claim 33 wherein said indicator is an estimation of MOE for a green felled log on the basis of an estimation of its density at or about 1000 kg/m^3.

35. The use of apparatus as claimed in any one of claims 1 to 34 for use in a method as claimed in any one of claims 32 to 34.

36. A method of generating and displaying an indicator of stiffness or fibre characteristics of wood within an elongate wooden structure (e.g. a log) which compris s or includes

(i) presenting an accelerometer based sensing means compliantly to an end of the elongate w oden structure,

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(ii) impacting that said end of the structure so as to generate an impulse capable of reflection from the other end thereof,

(iii) passing the analogue signal detected by said compliant sensing means to a processing means

(iv) processing the input data in said processing means to generate said indicator, and

(v) passing to the display means the generated indicator from said processing means for display,

wherein the architecture of the apparatus is such that said sensing means is a sensing head in which said accelerometer is compliantly mounted and is connected by a flexible link to a housing carrying said processing means and said display means.

37. A method as claimed in claim 36 wherein said sensing head has a switch capable of being initiated by applying pressure which is conducive to compliant contact of said accelerometer with the end of said wooden structure.

38. A method of any one of claims 31 to 35 wherein said same end is struck.

39. A method as claimed in claim 36 or 37 wherein said apparatus is apparatus as claimed in any one of claims 1 to 28.

40. A method of cutting a stem into logs of predicted speeds based upon the stem speed using the fact that the wave or acoustic speed along a stem has a characteristic variation by

(i) establishing an expression, the speed function, which represents the nature of the speed variation with distance along the stem, characteristic for a species and a locality, with one adjustable parameter to allow the variation along individual stems, to be matched,

(ii) measuring the average speed along the stem by a method in claim 31 or 32 and converting this to a stem transit time,

(iii) integrating the wave travel time along the stem using the speed function, and altering the adjustable parameter until the integrated time equals the measured stem transit time, and

(iv) using the speed function thus established to compute the likely speed at points along the stem, to mark and route logs accordingly.

41. A method of claim 40 which operatively uses apparatus of any one of claims 1 to 29.